The Waters of the Commonwealth

An Introduction to Massachusetts Hydrology

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The challenge – to assure…

- Adequate water to meet human demands
- Safe drinking water
- Healthy watersheds for aquatic biota

…for today and future generations

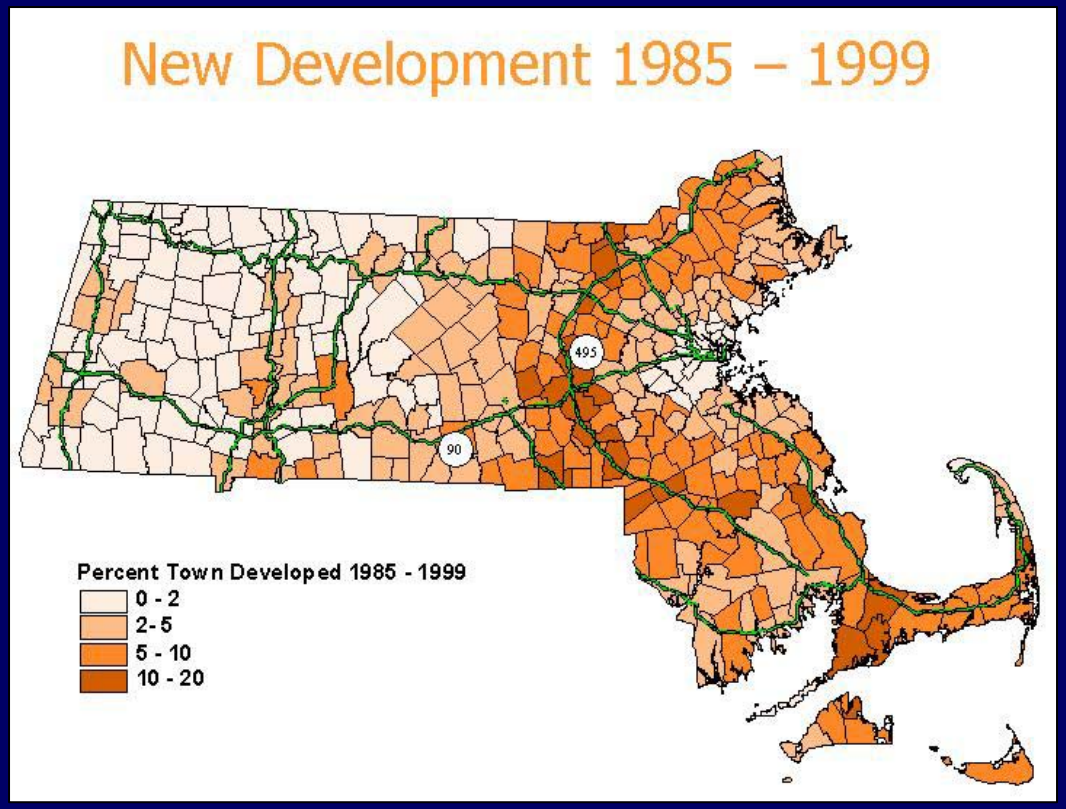
In the midst of…

- Changing land use
  (suburban sprawl)
- Changing water use
  (changing withdrawal/return-flow patterns)
- Changing water availability
  (seasonality, droughts,
  long-term climate change?)

Changing land-use…

- Sprawl will continue to impact quantity and quality of the Commonwealth's water resources.

- "Smart Growth"-- addressing environmental, housing, and transportation needs in an integrated fashion.



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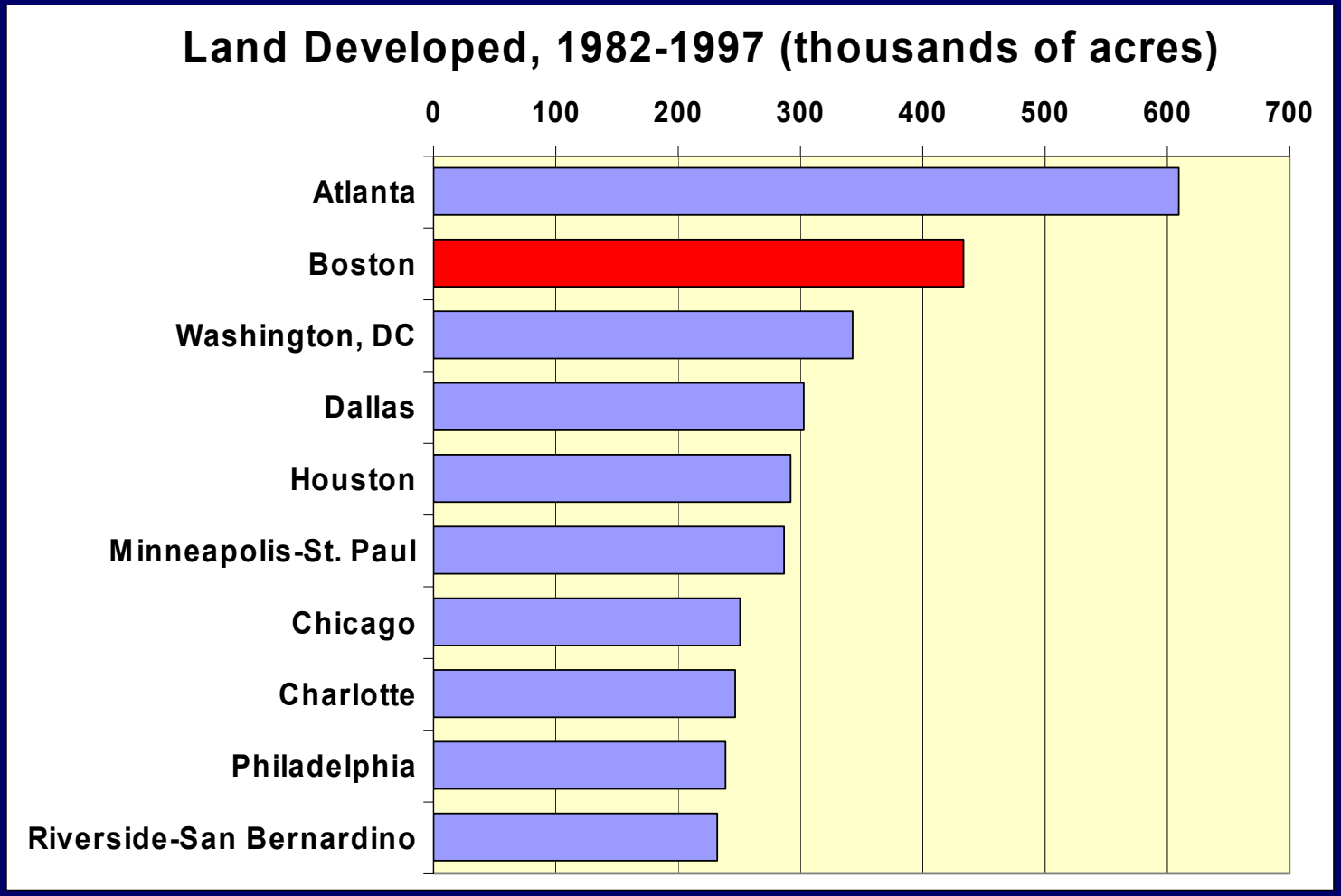
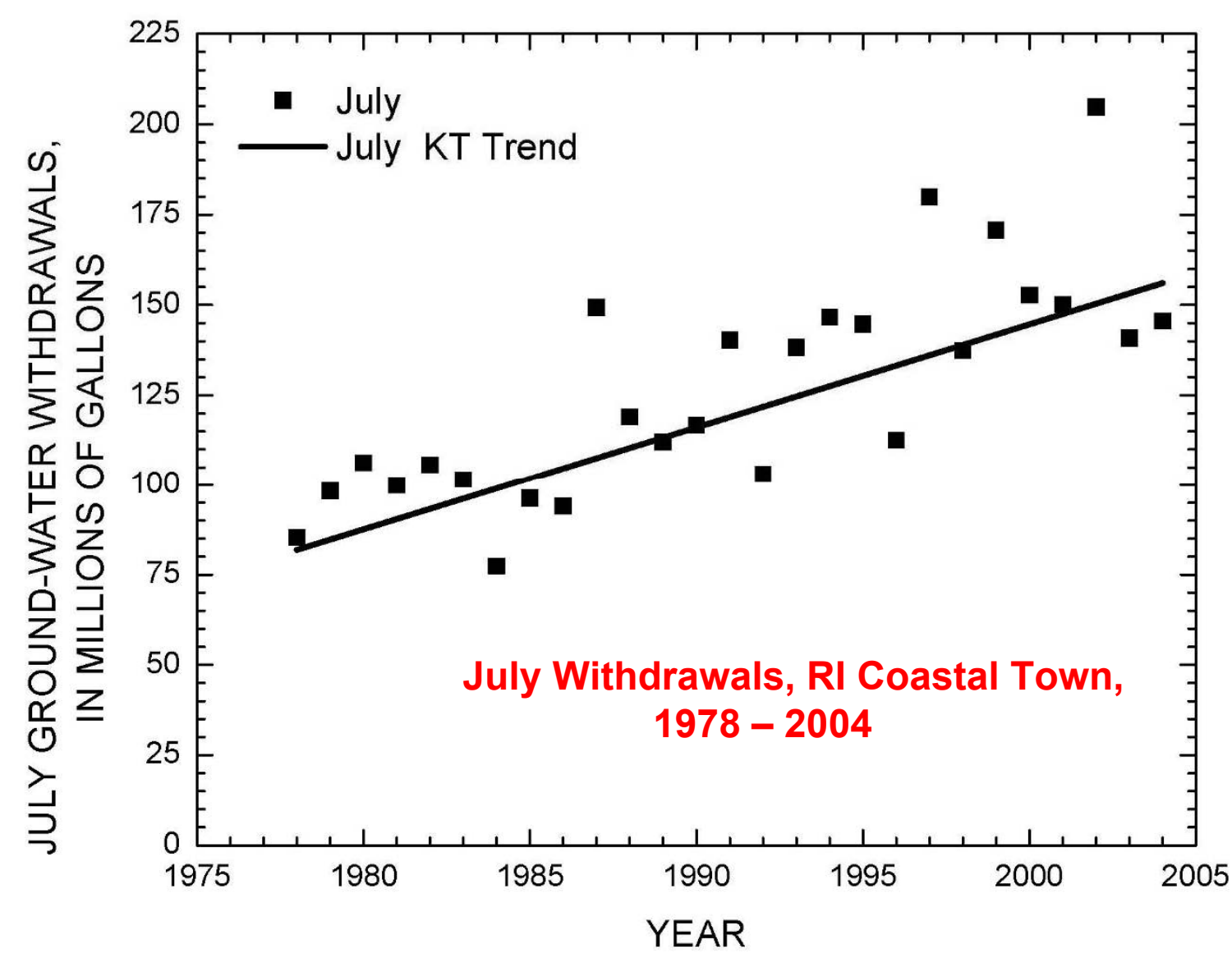
Changing land-use…

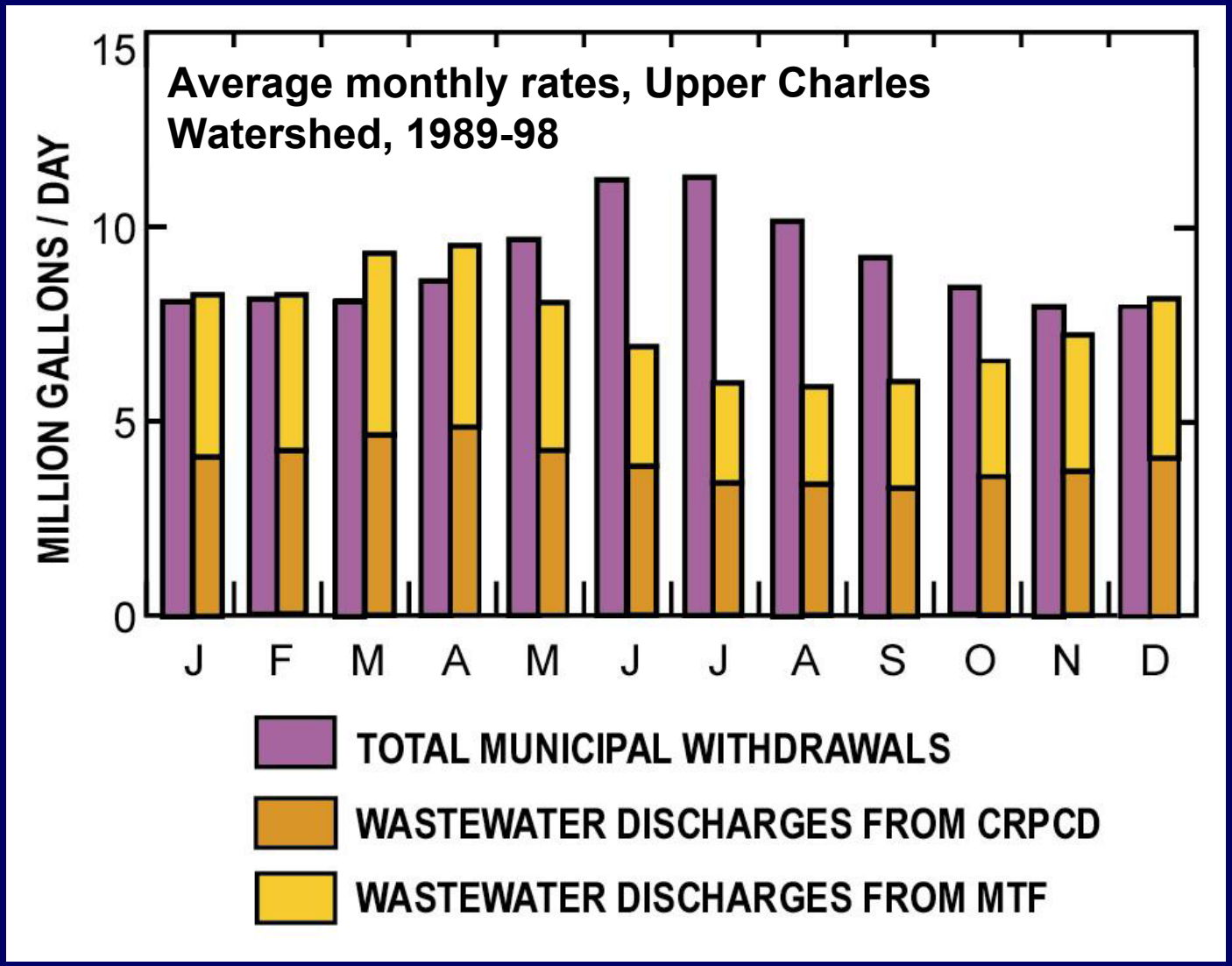


From: NRDC, 2003

Changing water-use…

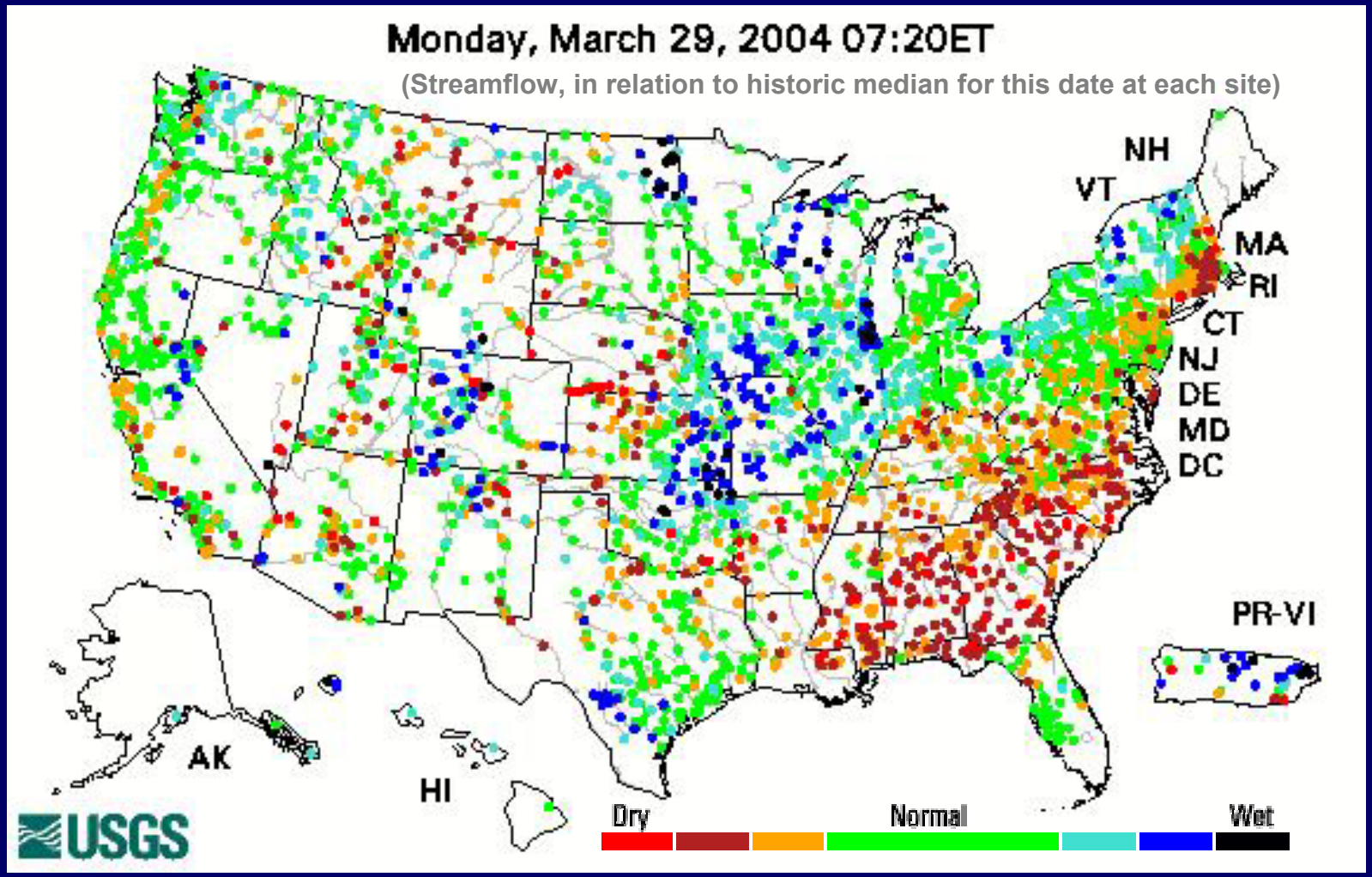


Changing water-use…



Changing water availability…

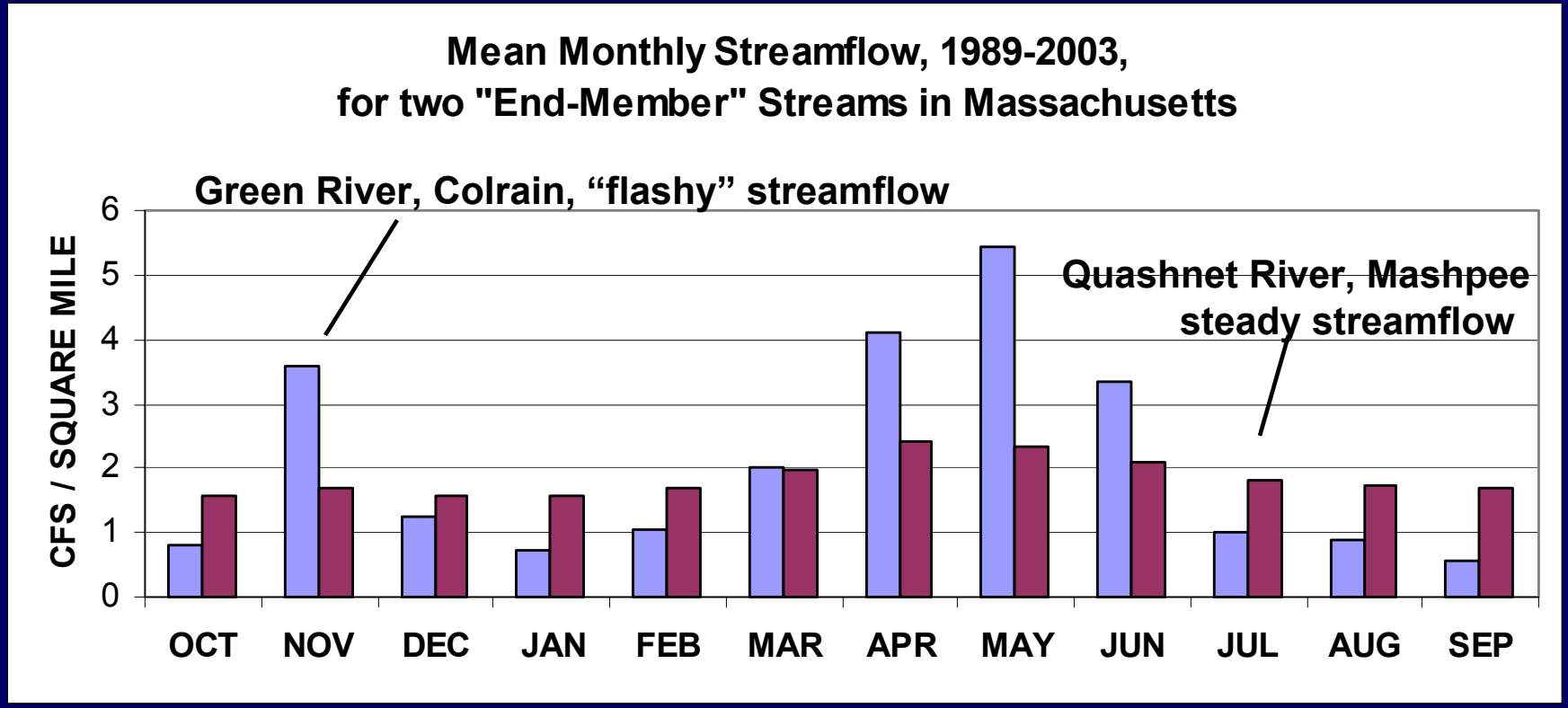
hourly to daily



http://water.usgs.gov/waterwatch/

Changing water availability:

the annual streamflow cycle, shown with monthly means



Green River– Western MA, steep basin, till dominated, frozen soils in winter

Quashnet River– Coastal MA, flat basin, sand-dominated, temperate winter

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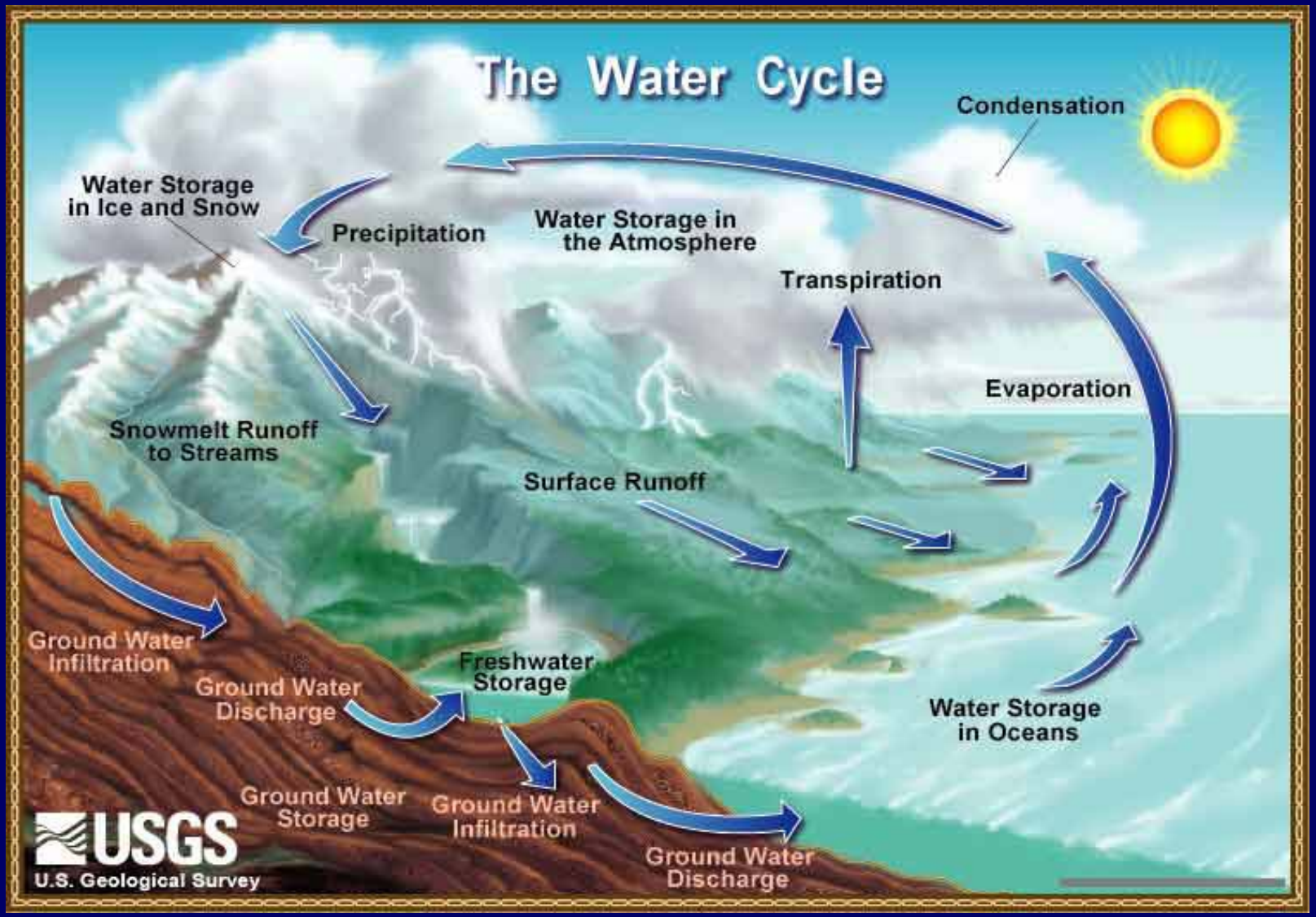
Improved understanding is the first step…

- The hydrologic cycle in Massachusetts
- Watersheds, aquifers, streams, and stream/aquifer interaction
- The water balance concept

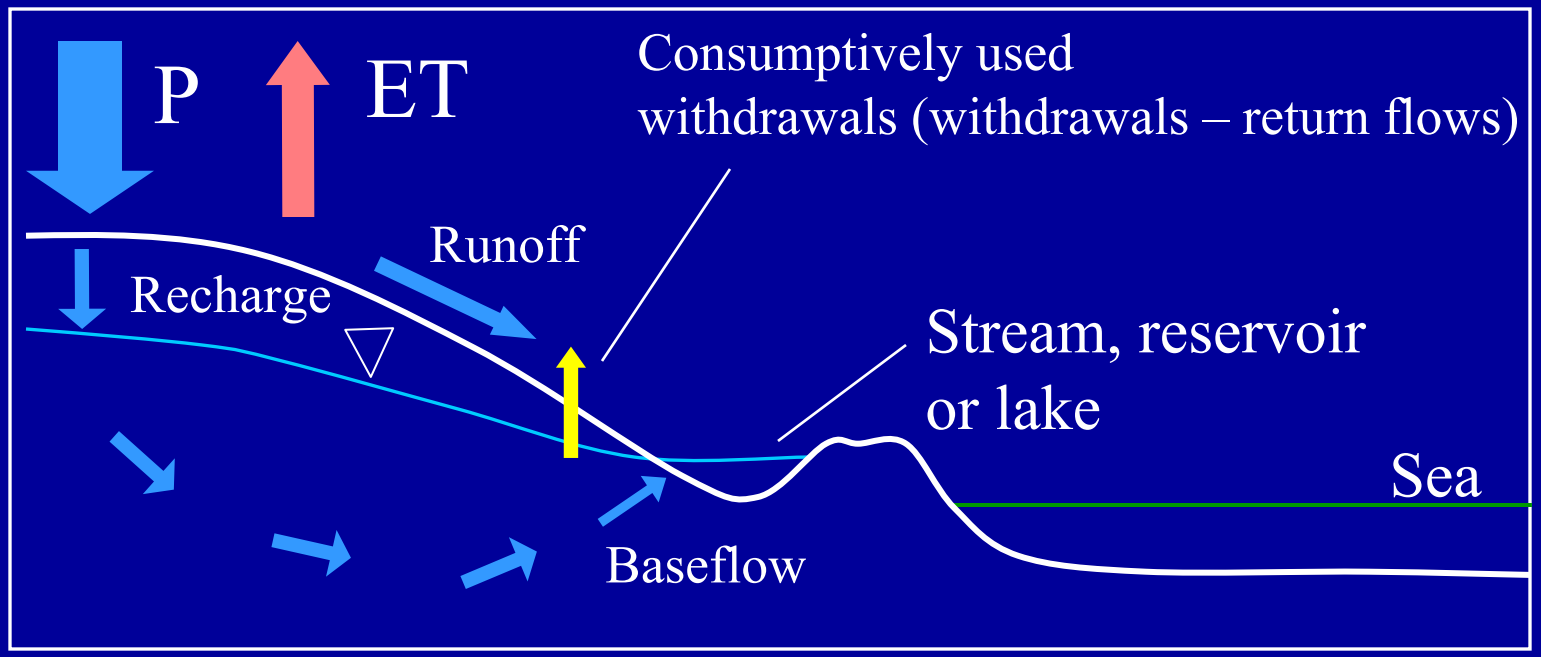
The water cycle:

(We've all seen some version of this pretty picture…)



The water cycle… *toward a quantitative understanding*

- In Mass., ample precipitation (44 in/yr), moderate ET (20 in/yr)



- P – ET = Rech + Runoff ; Recharge = Baseflow
- Rech + Runoff – ConsUse = Streamflow

(on average-annual basis)

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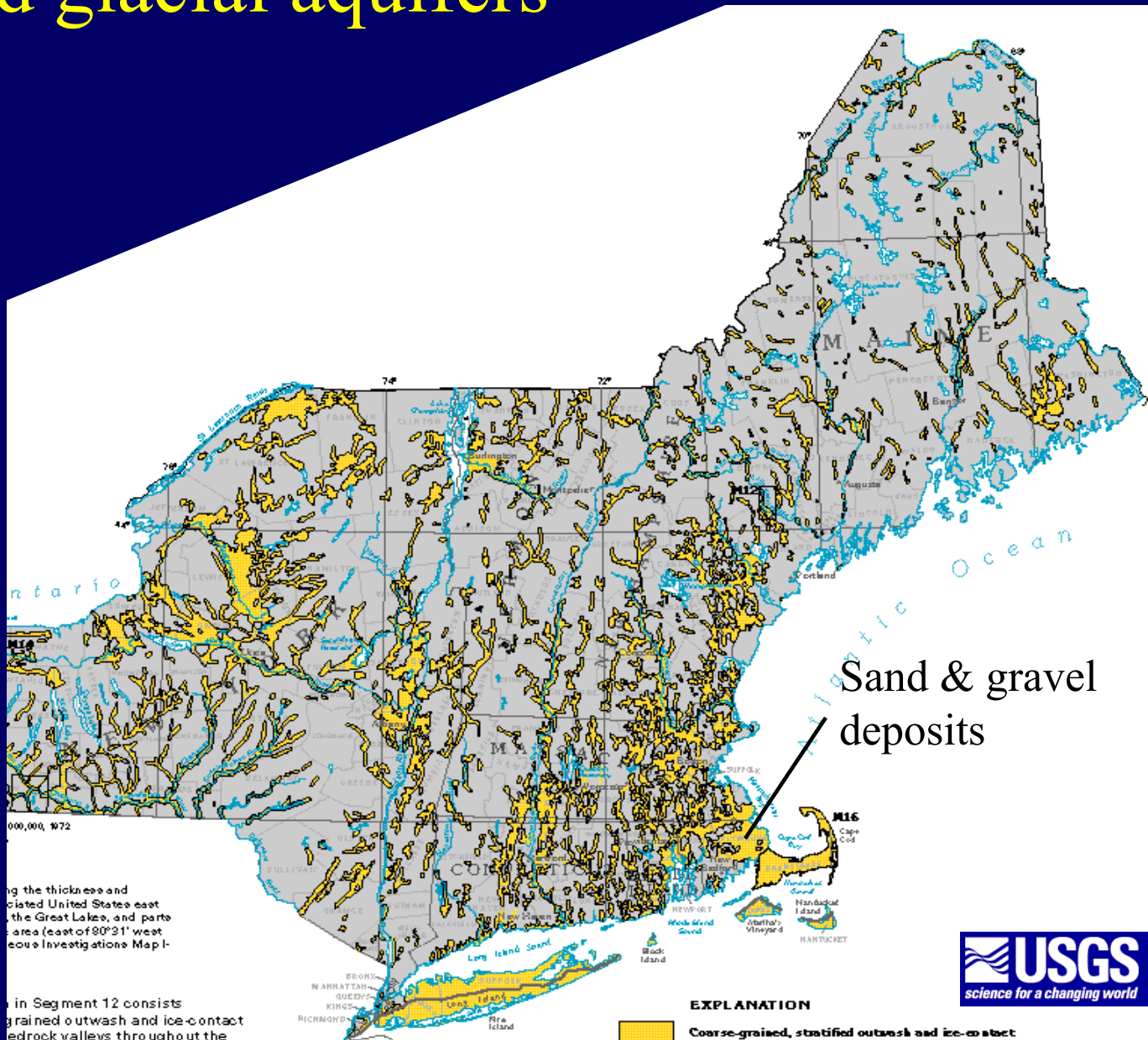
Major Massachusetts Aquifer Types:

- Glacial valley aquifer
- Outwash plain aquifer
- (Fractured crystalline rock aquifer)
- (Connecticut Valley sandstone aquifer)

New England glacial aquifers

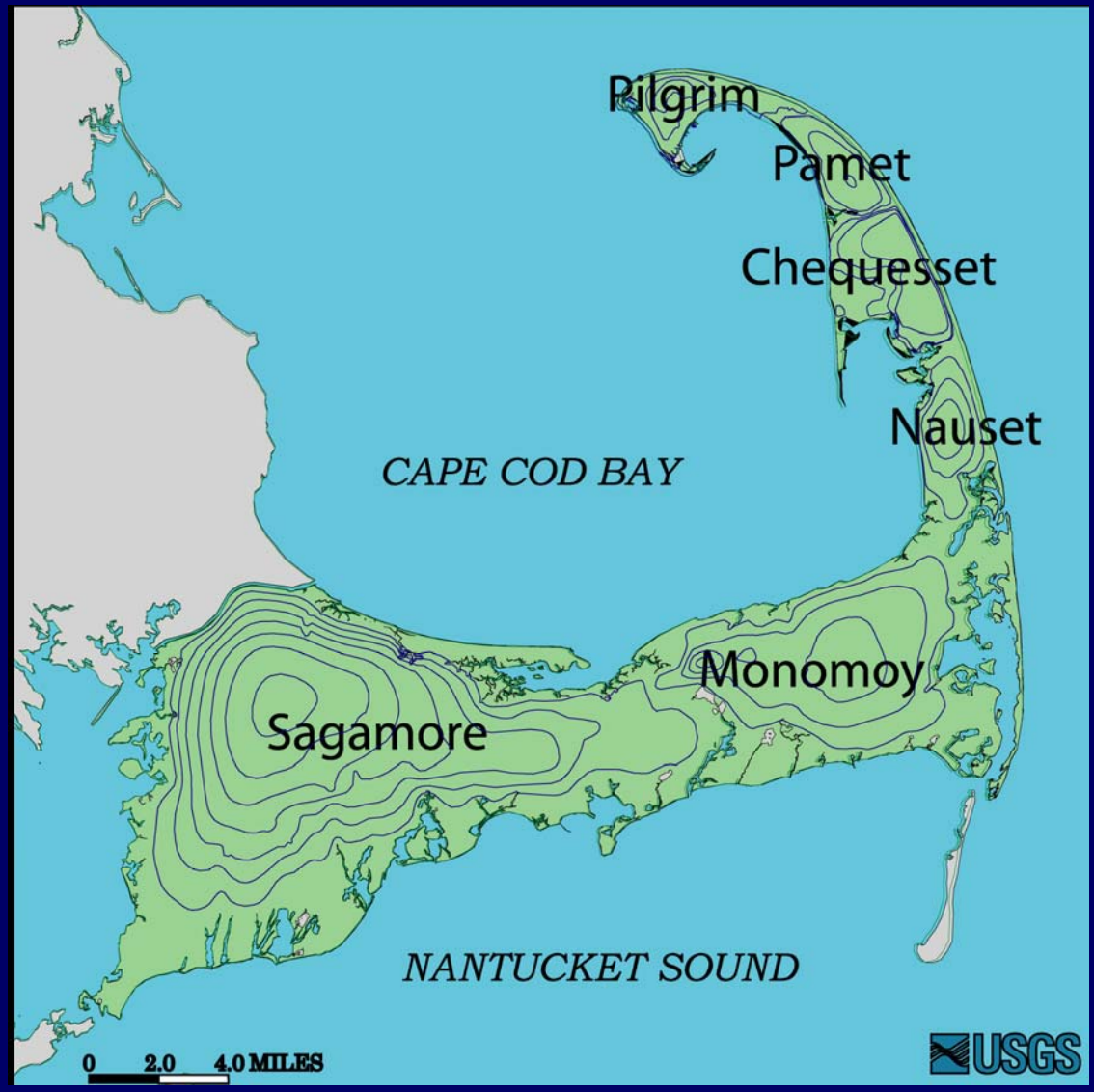


Map from:
USGS Ground Water Atlas of the United States

Outwash plain aquifer:

Cape Cod

- Thick, continuous sand & gravel deposits
- Distinct ground-water flow cells



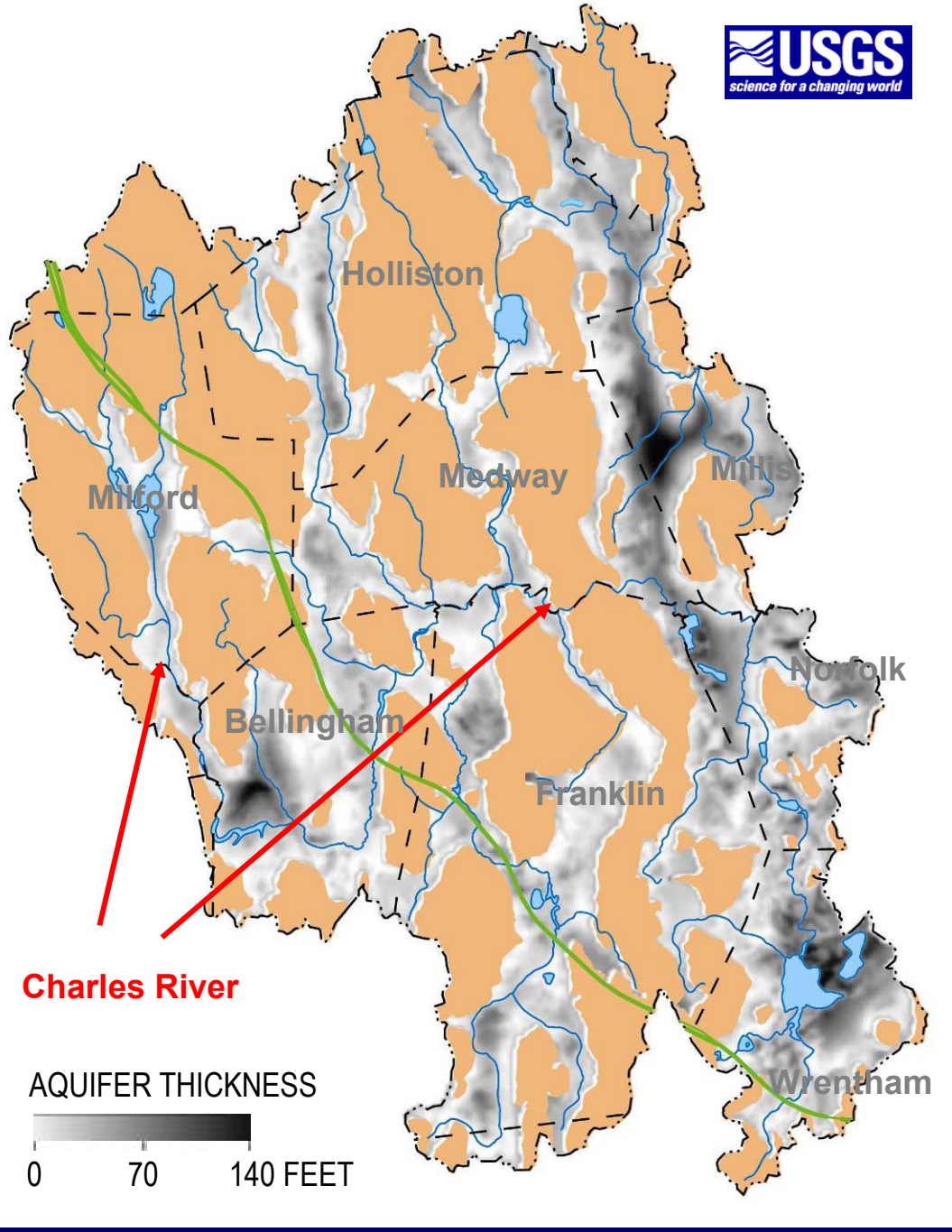
(Walter and Whealan, 2004)

Glacial valley aquifer:

Upper Charles River Basin

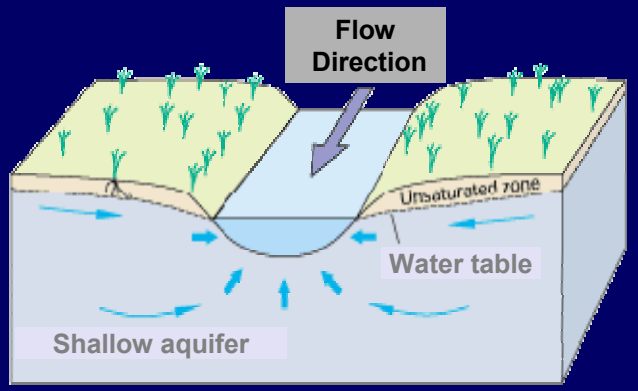
- Thin, discontinuous sand & gravel deposits
- In hydraulic contact with streams,lakes, and wetlands

(DeSimone and others, 2002)

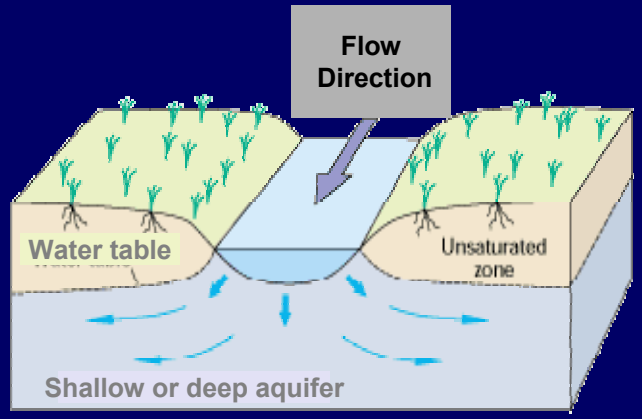


Stream/aquifer interaction:

- Naturally gaining stream (common in Massachusetts)



- Naturally losing stream (common in arid West)



http://water.usgs.gov/pubs/circ/circ1139/

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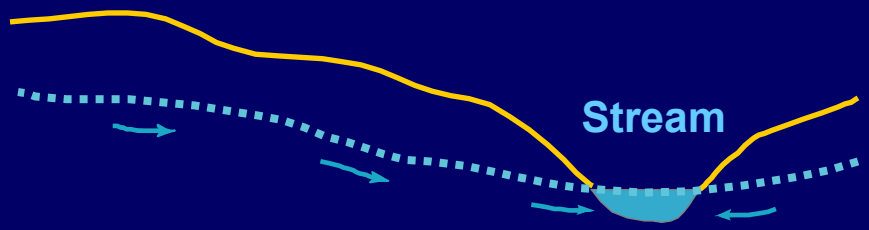
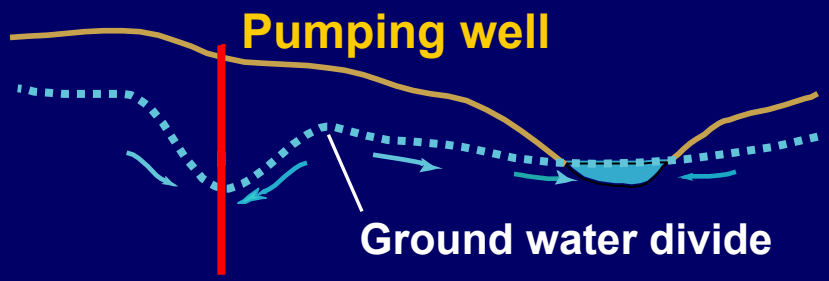
Artificially losing streams… (streamflow depletion)

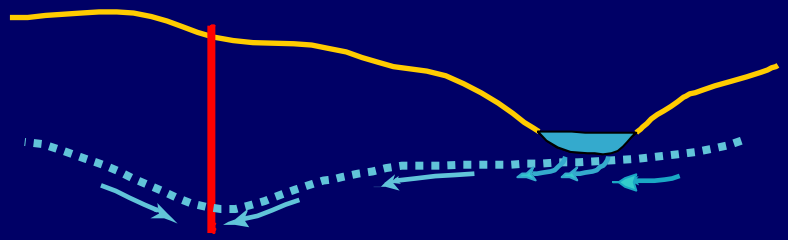
1. Pre-development



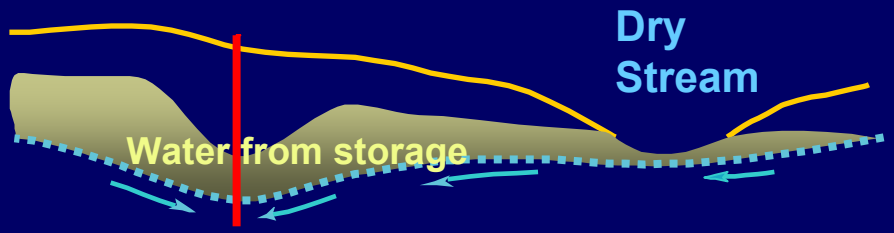
2. Captured recharge (or baseflow)



3. Induced infiltration



4. Depleted storage



(Zarriello and Ries, 2000)

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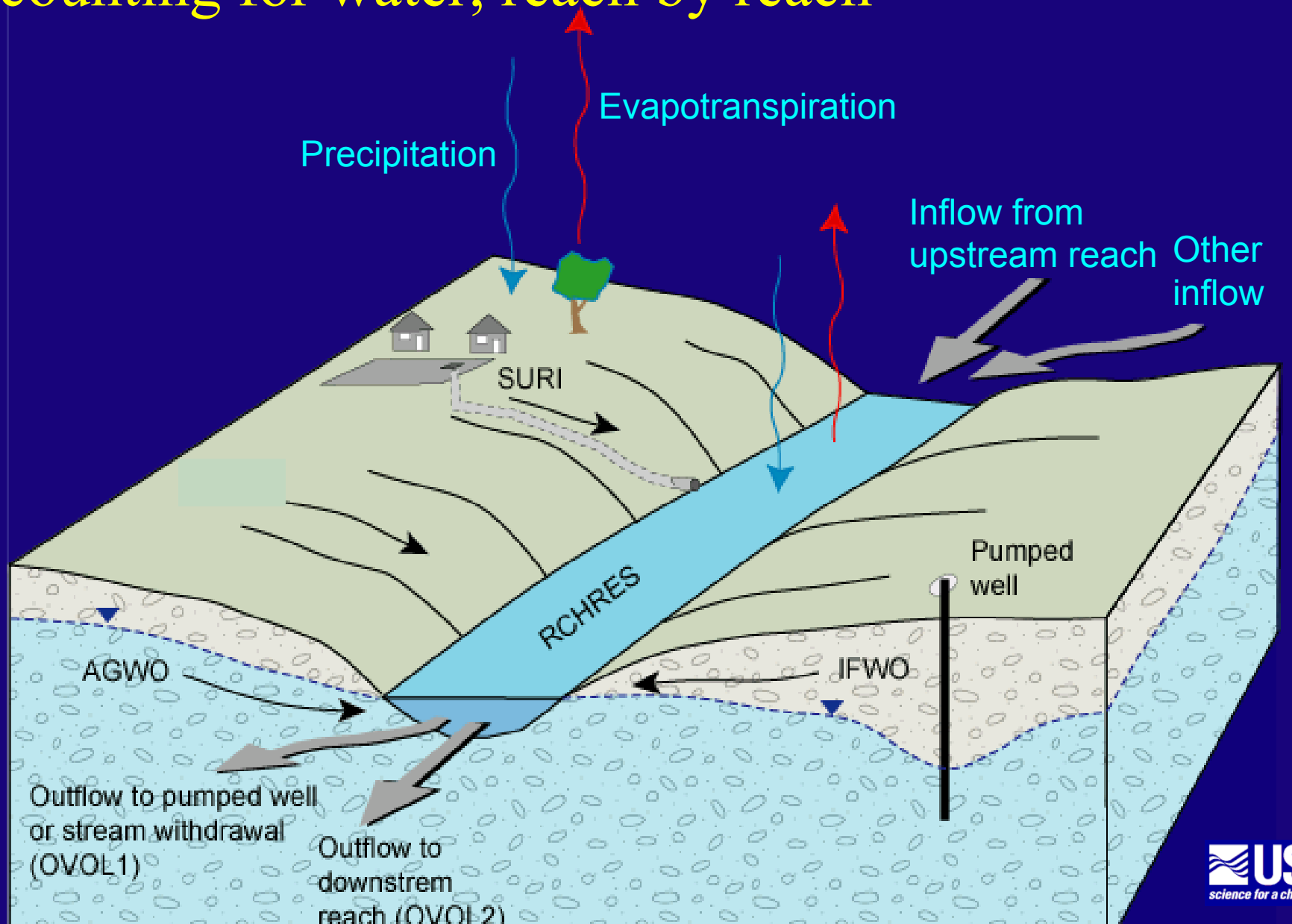
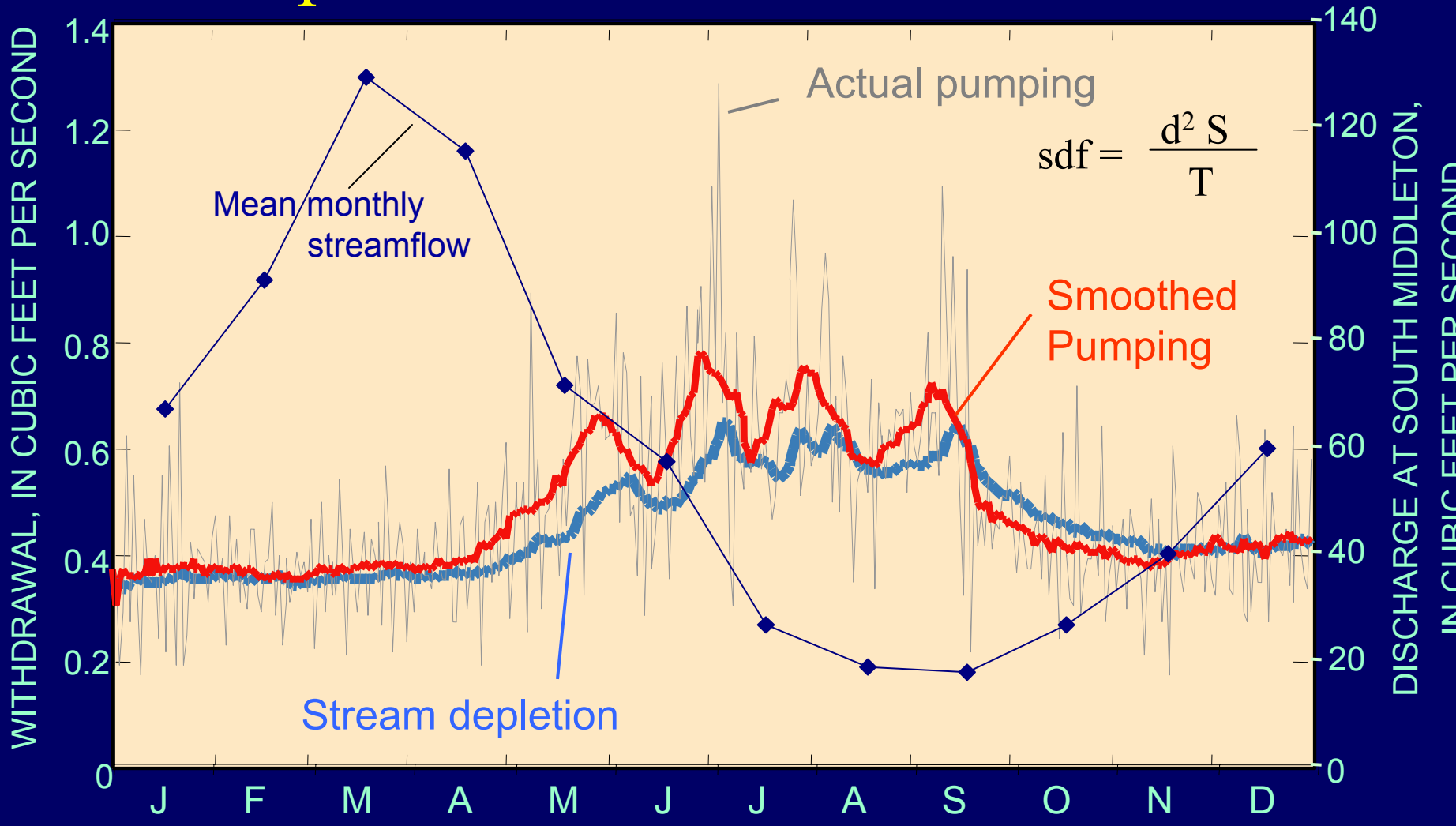
Watershed modeling:
Accounting for water, reach by reach

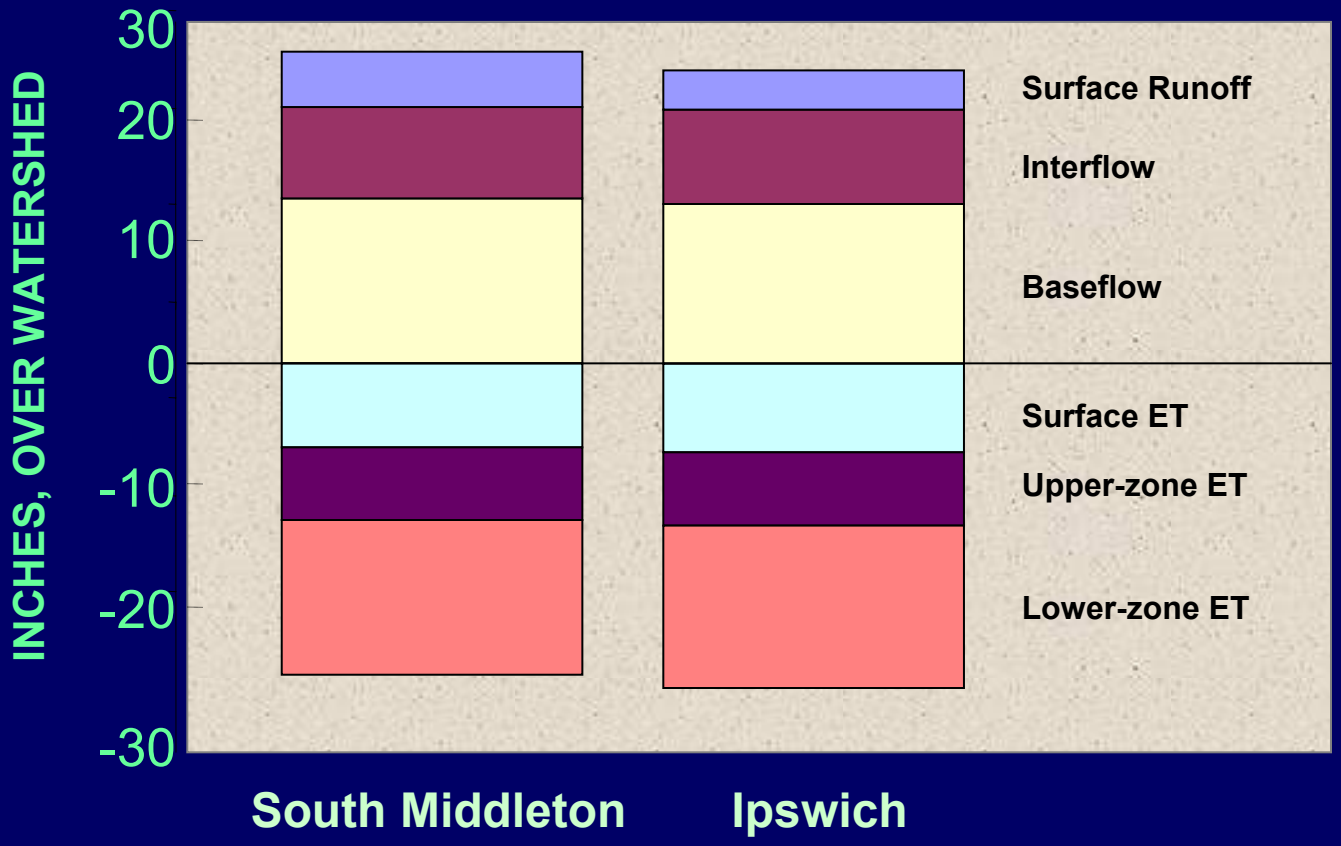


Simulating streamflow depletion

DEP No 3119-000-05G & 3119000-06G
300 & 720 feet from stream, respectively,
in Wenham



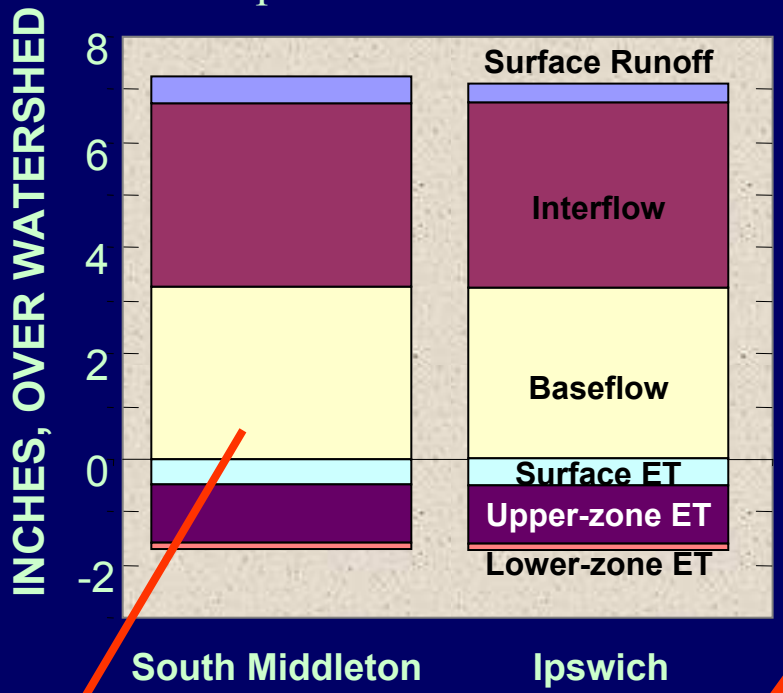
Annual Water Budget Components Ipswich River Basin, 1989-93



Monthly Water Budget Components

Wet month – April 1993

Precipitation - 5.36 inches



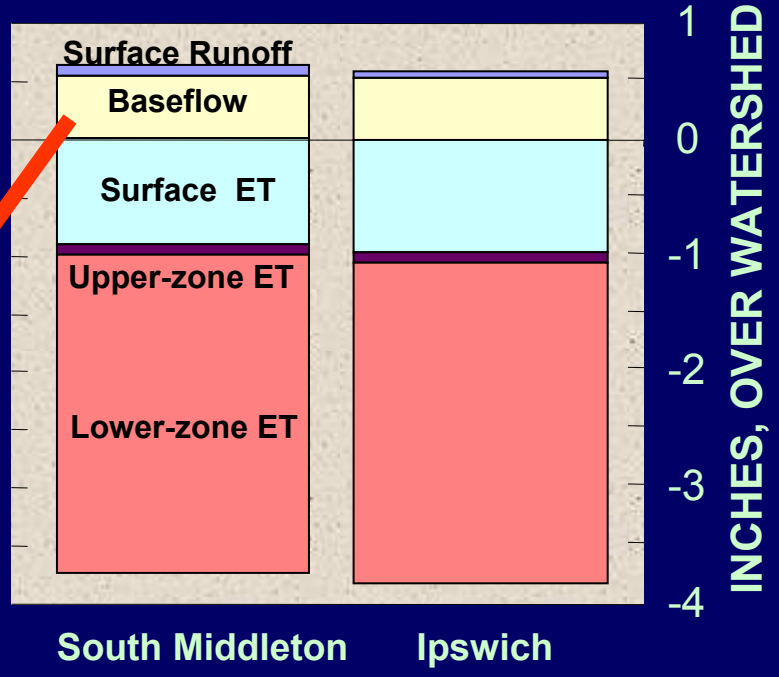
0.269 inches

0.419 inches

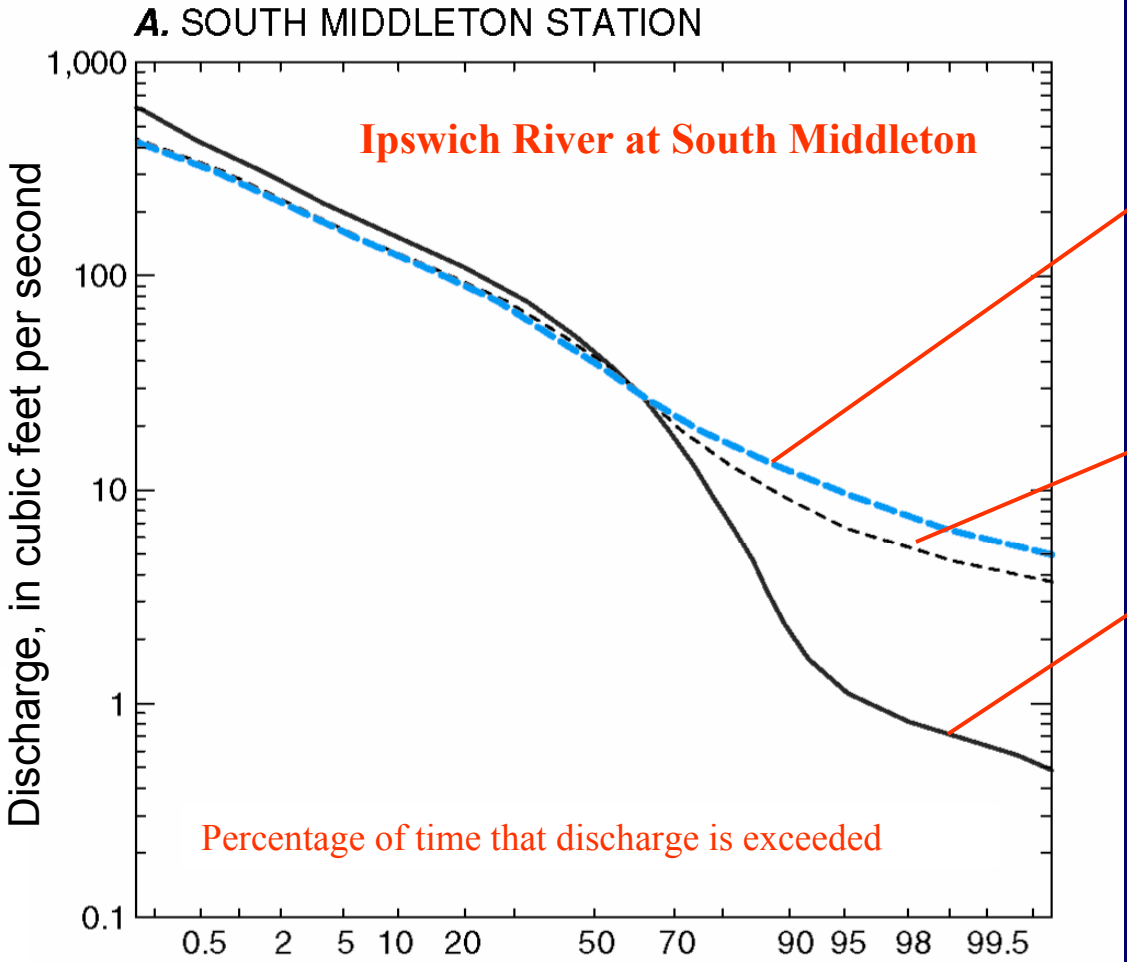
0.4 cfs = 0.009 cfsm

Dry month – July 1993

Precipitation - 1.64 inches



Modeled flows, Ipswich River Basin



Simulation results for:

No withdrawals, undeveloped land use

No withdrawals, 1991 land use

1989-93 withdrawals, 1991 land use

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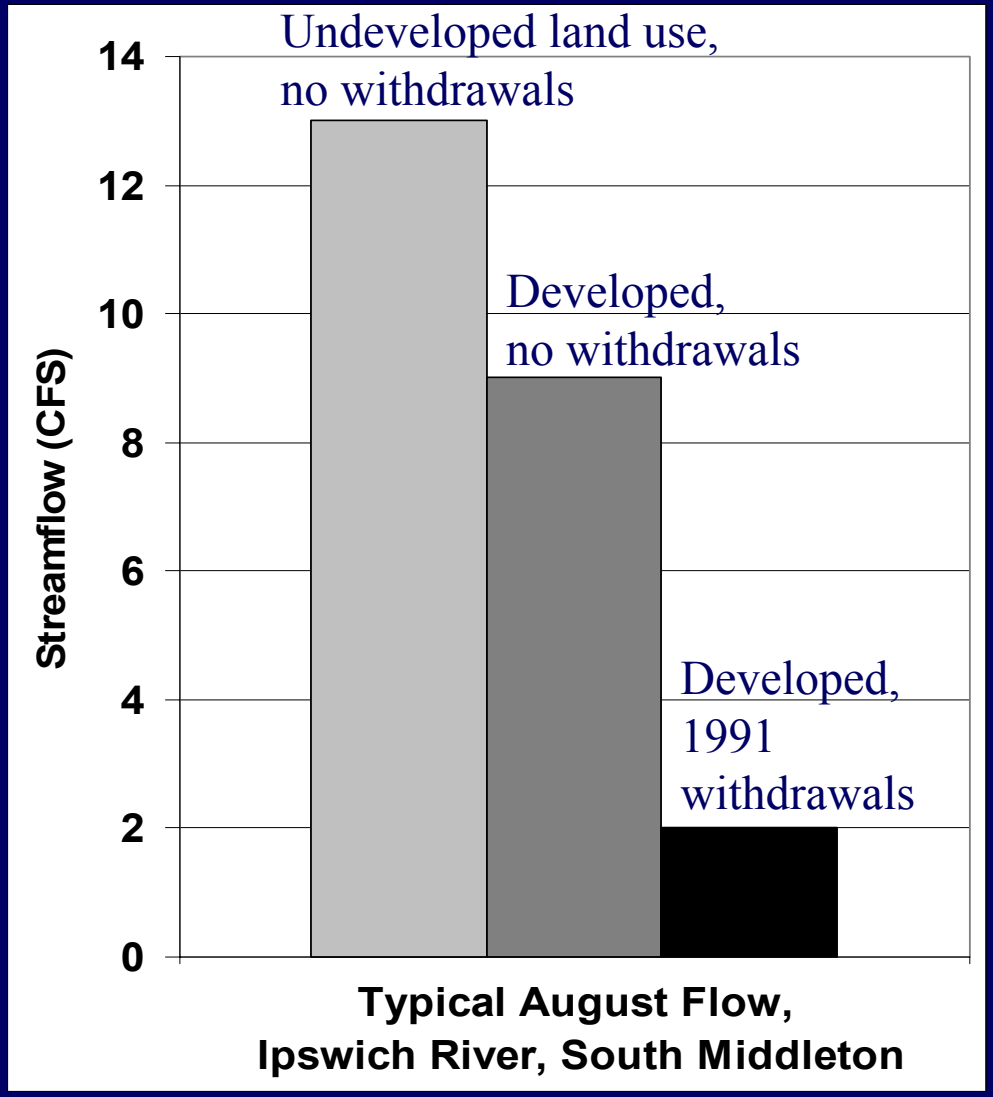
What is relative effect of withdrawals vs. land-use change on summer streamflows?

- It *depends* on pumping rates, locations of wells, geologic setting, and degree of urbanization.

- Model results for the Ipswich River show the relative effects of land-use change and withdrawals at South Middleton gage site.

(from Zarriello and Ries, 2000)



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Water-management to meet human and ecosystem needs in Massachusetts will typically include…

1. Increased recharge to aquifer (e.g., stormwater infiltration).

2. Bringing withdrawal cycle more into phase with recharge (e.g., demand management to reduce summer consumption).

3. Reducing use of streamside wells in the summer; relying more upon aquifer (or reservoir) storage away from streams in summer (operational flexibility).

4. Minimizing export of water and wastewater from basins (watershed-centered management).

Hydrologic models can be used to test options

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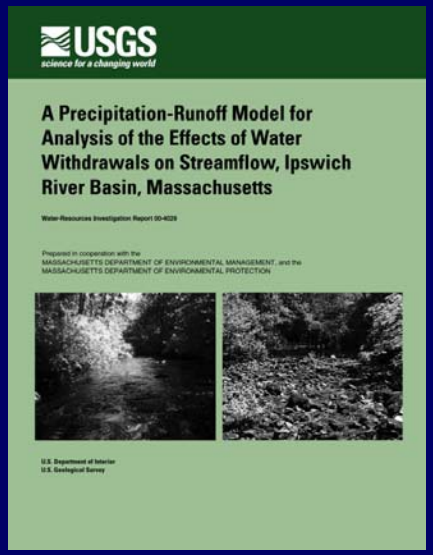
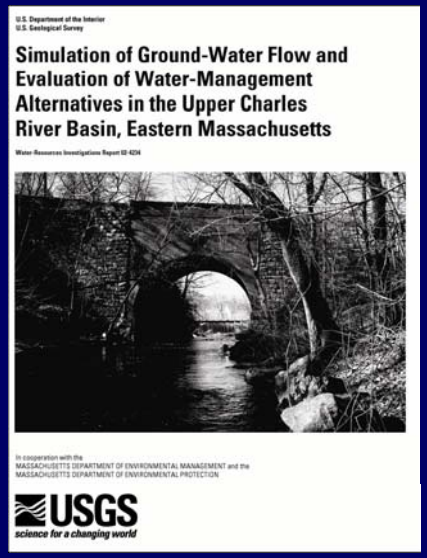


Recently completed USGS Basin Modeling and Habitat Reports:

- Ipswich Basin
- Upper Charles Basin
- Assabet Basin

http://ma.water.usgs.gov (click on publications)



Current MA Basin Studies, (each with a Technical Advisory Committee)

- Sudbury Basin
- I-495/MetroWest Region
- Blackstone Basin